Study on the acceptance and perception of stereoscopic 3D

Wolfgang Ruppel

RheinMain University of Applied Sciences, wolfgang.ruppel@hs-rm.de

Abstract

This paper presents the results of a survey among moviegoers on the acceptance of stereo 3D and the results of a study on the perception of certain stereoscopic effects. Based on these results, technical recommendations for the production and presentation of stereoscopic 3D are being given.

1. Introduction

The current stereo 3D hype raises the question how stereo 3D is being received by the audiences and which effects might affect the stereoscopic perception.

For quantifying the acceptance of stereo 3D, RheinMain University has conducted a survey among moviegoers and a study on the perception of certain stereoscopic effects.

2. Study among moviegoers on the acceptance of stereoscopic 3D

Earlier studies have shown that a significant percentage of the population suffers from reduced stereoscopic perception. Usually, these studies differentiate between three classes of wide-field disparity ranges, corresponding to crossed (near), uncrossed (far), and zero disparities. The percentage of the population being unable to fuse images according to at least one of these classes is about 30%. As a result, around 3% of the population must be assumed to be totally stereo-blind, not responding to all of the classes mentioned above ([1][2][3][4]).

Having that in mind, the focus of the survey summarized in this paper was on the acceptance of Stereo 3D, targeting the two main aspects of (1) Wearing comfort of the 3D glasses and (2) Problems when watching Stereo 3D in general. Side aspects like a potential correlation of the results with the wearing of additional optical glasses and with the seating position in the theater have been investigated as well.

The methodology selected was a structured survey among moviegoers. Moviegoers were asked to fill in a survey form after having watched a stereo 3D screening in a movie theater. All moviegoers have seen the first release of “Avatar 3D” in November 2009. A total of 850 forms have been distributed, and 260 of them have been filled in and returned

The evaluated 3D systems included RealD (with a double projection), Dolby 3D, Xpand and MasterImage. All of the projectors were TI DLP Cinema™ based projectors.

2.1. Wearing comfort of 3D glasses

The overall results on this question are summarized in **Fig. 1**: 15% of the moviegoers judged 3D glasses being "uncomfortable", whereas a majority of 85% found them being either "comfortable" or at least "OK".

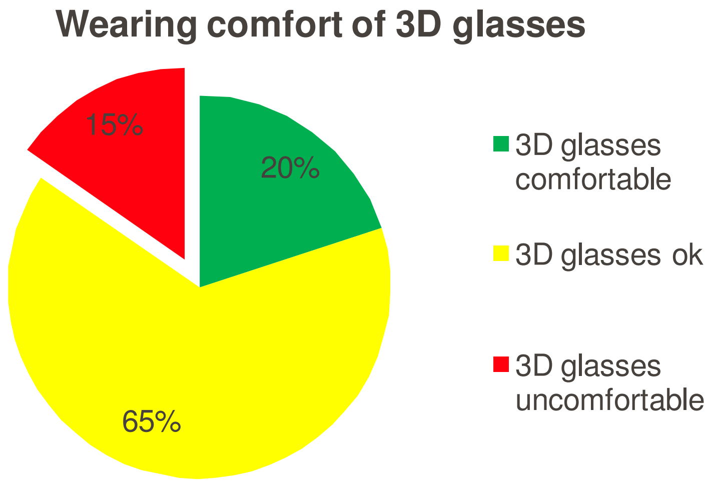

Fig. 1: Wearing comfort of 3D glasses

Detailing the results further by 3D systems gives insight into 3D system specific findings. **Fig. 2** shows that the Xpand glasses were rated most uncomfortable which corresponds to those glasses being the heaviest ones among all digital cinema 3D systems.

The differences between the other three 3D systems MasterImage, Dolby 3D and RealD, should not be over-estimated having in mind statistical deviations.

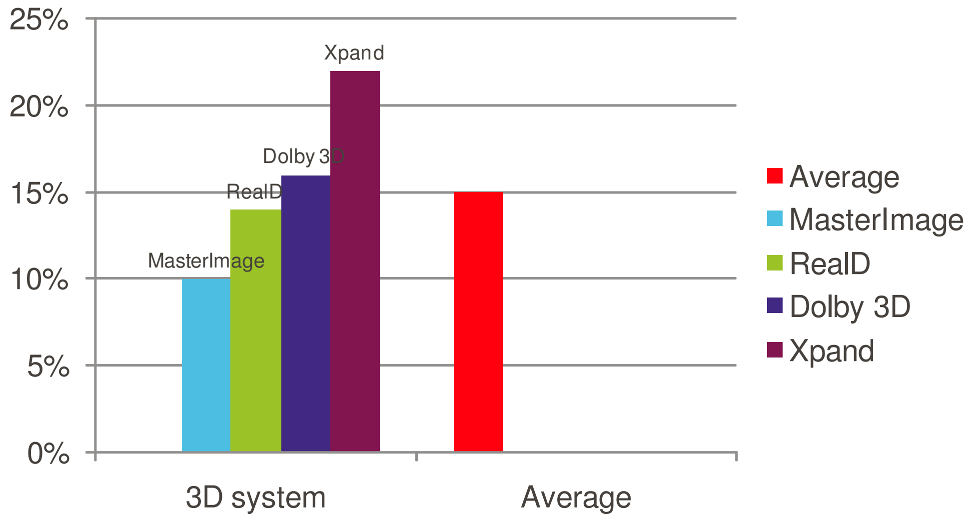

Fig. 2: Percentage of „3D glasses uncomfortable" by 3D systems

2.2. Problems when watching 3D

The overall results on this question are summarized in **Fig. 3**: 18% of the moviegoers reported having had problems when watching stereoscopic 3D. Although the majority of these 18% has reported smaller issues or temporarily issues, it is still a significant percentage.

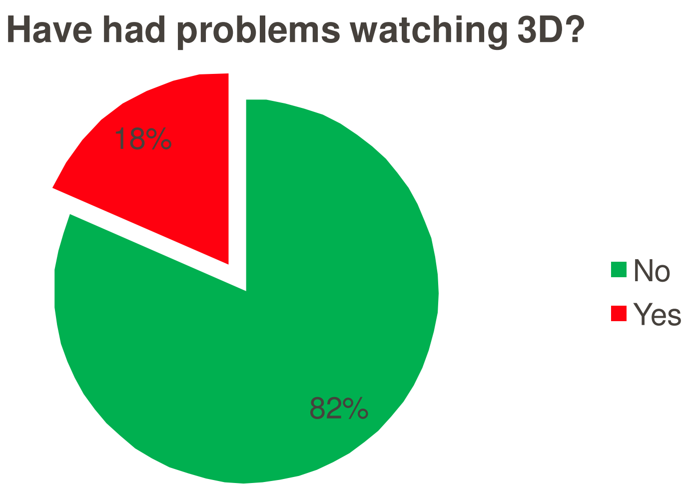

Fig. 3: Problems when watching 3D

When detailing the results on “problems with 3D“ by 3D systems, as depicted in **Fig. 4**, it becomes obvious that the Xpand system was rated significantly less problem-causing than the other three systems. The differences between MasterImage, RealD and Dolby 3D are within the statistical deviations and are not considered being significant.

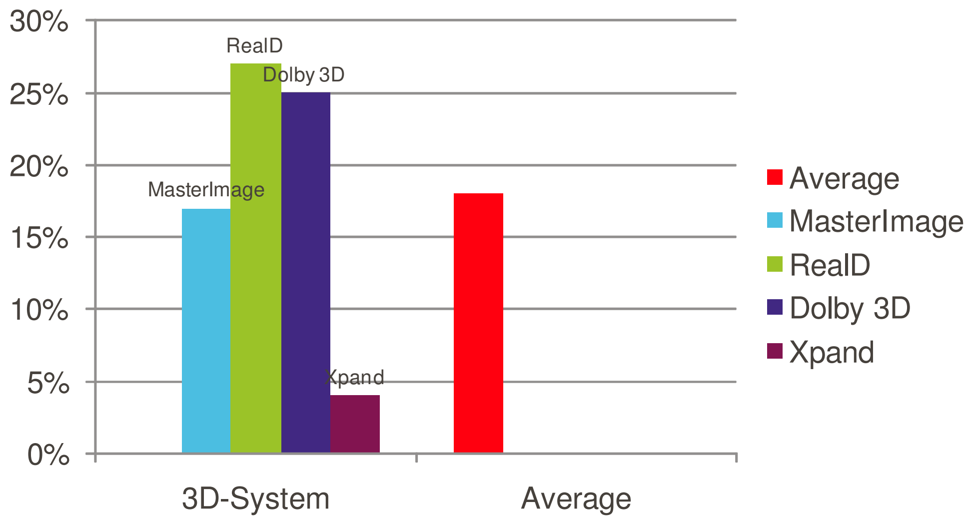

Fig. 4: Percentage of moviegoers having reported problems by 3D systems

We have not found a significant difference between the group wearing optical glasses in addition to the 3D glasses and the group without optical glasses.

We have found a higher percentage of female moviegoers reporting problems (21%) compared to male moviegoers (16 %). A reason may be the smaller interocular distance of women.

Regarding the seating position in the theater, we have found significantly different percentages of people reporting problems. **Fig. 5** shows that sitting in the front rows and on the seats on the sides give the worst stereoscopic experience.

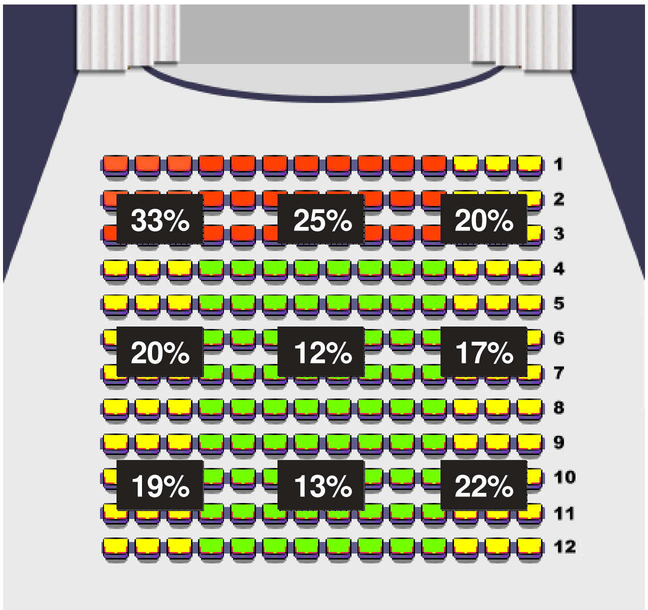

Fig. 5: Percentage of moviegoers having reported problems by seating position

3. Study on the perception of certain stereoscopic effects

Chapter 2 has shown that a significant number of moviegoers are experiencing discomfort with the 3D glasses and the stereoscopic perception in general. Based on these results, RheinMain University has conducted a study with test persons in order to evaluate the effect of certain stereoscopic effects on the stereoscopic perception and in order to find hints how the perception and acceptance of Stereo 3D can be improved.

The effects under study have been (1) amount of objects with negative parallax in a given scene, (2) vertical parallax and (3) window violations. This list of effects is a first starting point and does not claim to be complete.

3.1. Amount of objects with negative parallax in a given scene

The test pictures used for this effect were showing a limited-depth scene shot in a TV studio. (**Fig. 6**). The scene has been shot with parallel cameras, and the convergence point (the plane of zero parallax) has been adjusted during post processing. We have shown four pictures of this scene to the test persons. The first picture had the screen plane (with zero parallax) in the foreground and therefore all objects had a positive parallax value, i.e. they appeared behind the screen. For the following three pictures, the screen plane was moved into the scene leading to an increasing number of objects with negative parallax, i.e. appearing in front of the screen. The fourth picture had negative parallax only; the screen plane of this picture was on the blue curtain in the background making all of the objects appearing in front of the screen.

Fig. 6: Test picture for parallax tests

The results were quite noticeable: The first picture, the one entirely "behind the screen", was judged by 74% as being pleasant. The last picture, with negative parallax only, has only been judged by 40% as being pleasant. The other two were in between.

Therefore, it can be concluded that negative parallax stresses the eyes and may lead to unpleasant stereoscopic perception.

3.2. Vertical parallax

Vertical parallax does not occur in reality and may strain the eyes by forcing them to vertically diverge.

The same test picture as described above has again been used for testing the effect of a vertical parallax.

In this experiment, the amount of artificial vertical parallax has been increased from one pixel up to 20 pixels.

It turned out that even a very small amount (above 1 pixel) of vertical parallax leads to a decreased percentage of test persons judging the picture as "pleasant".

Therefore, it is very important to avoid or correct the occurrence of vertical parallax in stereoscopic 3D.

3.3. Window violations

A window violation occurs if an object appears in front of the screen plane (negative parallax) but is nevertheless being cut by the picture frame. This is a situation that cannot be resolved by the human brain, because in reality, objects that are in front of a window (in this case the stereoscopic window) are usually fully viewed and not being cut.

One solution to overcome window violations is the introduction of a floating window. A floating window moves the stereoscopic window in the direction of the viewer by introducing properly sized black bars on the left hand and right hand borders of the picture. For details see [6].

In our study, we have compared a scene with a window violation with the same scene when a floating window has been inserted in addition.

The result was as expected: With the window violation, only 65% of the test persons judged the scene as "pleasant". After the introduction of the floating window, as much as 95% judged the same scene as "pleasant".

There, it can be concluded that window violations affect stereoscopic perception and should either be avoided in production of corrected by a floating window afterwards.

4. Conclusions

A survey among moviegoers has shown that 18% of the moviegoers have reported problems when watching stereoscopic 3D. Although in most cases slight or temporarily problems only have been indicated, this percentage is not negligible.

Earlier studies (e.g. [5]) have already shown the effect of technical parameters on the stereoscopic perception. Our study has lead to further insight into the influence of parallax budget, vertical parallax and window violations on stereoscopic perception. The importance of technical production rules became obvious.

As a result, the following rules might be considered when shooting stereoscopic 3D:

- Use negative parallax rarely and with care
- Avoid or correct window violations
- Avoid vertical parallax
- Avoid fast moves and zooms
- Avoid fast cuts, adapt the convergence point between successive scenes

Further information on production rules can be found e.g. in [7] and [8].

5. Acknowledgements

The author wishes to thank all students and scientists of RheinMain University having contributed to this report. In particular, the results are widely based on the diploma thesis of Yvonne Thomas [9].

The author wishes to thank MikroM GmbH, Lux Media Plan, Flying Eye and HFF Potsdam for their respective support and cooperation.

The work has been funded by the German Ministry of Education and Research Project (Funding No. 17N4209).

6. References

[1] Richards, Whitman: "Stereopsis and Stereoblindness", *Exp. Brain Res. 10, 380-388 (1970)*

[2] Richards, Whitman: "Anomalous stereoscopic depth perception", *Journal of the Optical Society of America, 61/1971, S. 410-419*

[3] Van Ee, Raymond: "Correlation between stereoanomaly and perceived depth when disparity and motion interact in binocular matching", *Perception, 32/2003,S. 67-84.*

[4] http://visionscience.com/pipermail/visionlist/2010/003623.html, *called on 01.11.2010*

[5] Banks, Martin: ”Steroscopic Vision: How Do We See in 3D?”, *NAB Digital Cinema Summit 2009*

[6] Walt Disney Studios Motion Pictures: “3D Floating Windows Guide”, http://digitalcinema.disney.com , *called on 01.11.2010*

[7] Mendiburu, Bernard: “3D Movie Making: Stereoscopic Digital Cinema from Script to Screen”, *Focal Press 2009*

[8] Ten Commandments of Stereoscopy, http://www.stereoscopynews.com/download/software/923-qthe-ten-commandments-of-stereoscopy.html , *called on 01.11.2010*

[9] Thomas, Yvonne: „Untersuchung der stereoskopischen Wahrnehmung in Abhängigkeit verschiedener Displaygrößen und Erstellung einer Studie zur Akzeptanz von 3D“, Diplomarbeit, *Hochschule RheinMain, August 2010 (in German)*